REQ. NO. 1-9142

Recovery of Continuous Drill Core Samples for Microbiological Profiles from the Nordic Tailings Deposit, Elliot Lake, Ontario

CONTRACT REPORT NO. OSQ82-00023

Final Report

by

Site Investigation Services, Peterborough, Ontario

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

DSS FILE NUMBER	:	03SQ 23440-1-9142
DSS CONTRACT SERIAL NUMBER	:	OSQ82-00023
CANMET PROJECT NUMBER	:	3.5.0.0.01
CANMET SCIENTIFIC AUTHORITY	:	M. Silver

14 pp

DATE: October, 1982

This report should be cited as Contract Report No.: OSQ 82-00023.

MEMO

DATE 20/12/82

TO: Mrs Campbell

FROM: W.A. Gow, Direct

To: H.M. Parsons & M. Silver

NOTE AND RETURN

NOTE AND FILE

DRAFT REPLY

COMMENTS

Please have M. Silver complete the attached by 14/1/83 & return to this office.

Donnie

ON NO: 1-9-42

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Division. Any CONFIDENTIAL reports shall be retained by the Scientific Authority. Note that all data in Summary Sheets must be in S.I. units.

CANMET CONTRACT SUMMARY SHEET

TITLE: RECOVERY OF CONTINUOUS DRILL CORE SAMPLES FOR MICROBIOLOGICAL PROFILES FROM THE NORDIC TAILINGS DEPOSIT, ELLIOT LAKE, ONTARIO

CONTRACTOR: Site Investigation Services

SCIENTIFIC AUTHORITY: Dr. M. Silver

TEL: 995-4738

BEGIN/END: 31 May, 1982/27 August, 1982

REQUISITION NUMBER: 1-9142

FUNDING $20,400.00

CANMET:

CONTRACTOR:

DSS:

OTHER:

TOTAL: $20,400.00

PROGRAM: MINERALS

ACTIVITY:

SUB-ACTIVITY: ENVIRONMENTAL TECHNOLOGY

SUB-SUB-ACTIVITY:

PROJECT: CONTROL OF URANIUM TAILINGS EFFLUENTS
PROJECT CODE: 3.5.0.0.01
PROJECT ELEMENT: ASSESSMENT OF BACTERIAL POPULATIONS IN THE NORDIC TAILINGS DEPOSIT

OBJECTIVES

To obtain continuous drill core samples of the Nordic tailings deposit from the surface to the underlying peat layer. To recover, contain and transport drill core samples to a designated sample recovery area adjacent to the tailings deposit.

PROCEDURE

By use of a truck-mounted power auger drill equipped with a 4¼ inch (10.8 cm) hollow stem auger, 4 core samples from the Nordic tailings were obtained by advancing 3 inch (7.6 cm) diameter thin wall aluminium tubing by light tapping with a 140-pound drop hammer. The aluminium tubing was withdrawn and cut into 15 cm segments.

RESULTS

All 4 core samples were successfully obtained, cut into 15 cm segments, and delivered to M. Silver.

APPLICATION AND ONGOING WORK

Assessment of Bacterial Populations of the Nordic uranium tailings - Report in preparation.

SUPPORTING DOCUMENTS

3 copies "Report on Sampling Techniques Nordic Mines Tailings Deposit Elliot Lake, Ontario.
John A. Hayes, B.Sc., D.I.C., P. Eng.
Site Investigation Services.

REPORT ON SAMPLING TECHNIQUES
NORDIC MINES TAILINGS DEPOSIT
ELLIOT LAKE, ONTARIO

DR. M. SILVER
DEPARTMENT OF ENERGY MINES & RESOURCES
CANMET, MINERAL SCIENCES LABORATORIES
555 BOOTH STREET,
OTTAWA, ONTARIO. K1A 0G1

JOB #2698

OCTOBER 1982

SITE INVESTIGATION SERVICES
LIMITED

677 CROWN DRIVE PETERBOROUGH, ONT. PHONE 743-6850

OCTOBER 25, 1982

Department of Energy Mines & Resources,
CANMET, Mineral Sciences Laboratories,
555 Booth Street,
Ottawa, Ontario.

ATTENTION: DR. M. SILVER

Dear Marvin:

As promised, I have prepared the enclosed brief report for you outlining some of the practical sampling problems which we had to contend with at the Nordic Mines site.

I trust that this information will be useful to you. If you have any further queries, don't hesitate to contact me at your convenience.

Yours very truly,

John Hayes

JOHN A. HAYES, B.Sc., D.I.C., P. Eng.,
Geotechnical Eng.
FOR SITE INVESTIGATION SERVICES LTD.

/mf

NORDIC MINES TAILINGS DEPOSIT

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NATURE OF THE MATERIAL

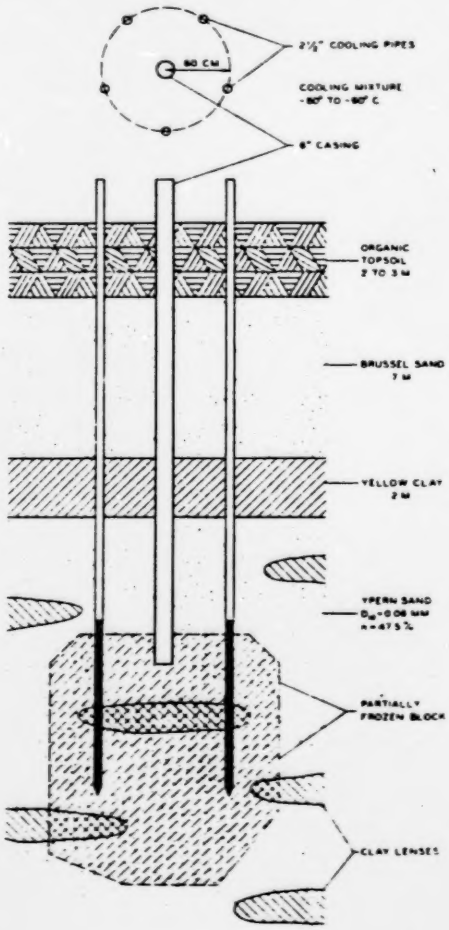
The tailings material consists mainly of very fine sand, silt and some clay-sized particles. The material was deposited in a very loose state and, except for a somewhat compacted crustal zone near the surface, remains in a relatively loose state. The porosity of the material (ratio of void volume to total volume of voids and solids) is estimated to range from 47% to 52% in the loose state to about 23% to 29% in a compact or dense state. The permeability coefficient of the materials sampled is estimated to range from 10^{-3} to 10^{-5} cm/sec., with 10^{-4} cm/sec. being a reasonable average.

Above the ground water table the tailings are moist, but not saturated, except in the capillary zone just above the water table. In the capillary zone and below the water table the soils are saturated.

SAMPLING PROBLEMS

The materials described above are some of the most difficult for the geotechnical engineer to sample. Because of their very loose condition they tend to compact when disturbed, even by very small forces. The pushing, vibration and cutting loads induced by the gentlest of sampling procedures will cause a decrease in volume of the sample due to reduction of the volume of voids.

The only positive way to obtain a structurally undisturbed sample of such materials is to solidify the material by impregnation of the voids with hardening chemicals or by freezing of the soil. A description of this method used by Langer and Kollbrunner in soils very similar to those at the Nordic site follows -



PARTIAL FREEZING BEFORE SAMPLING

FIG 251

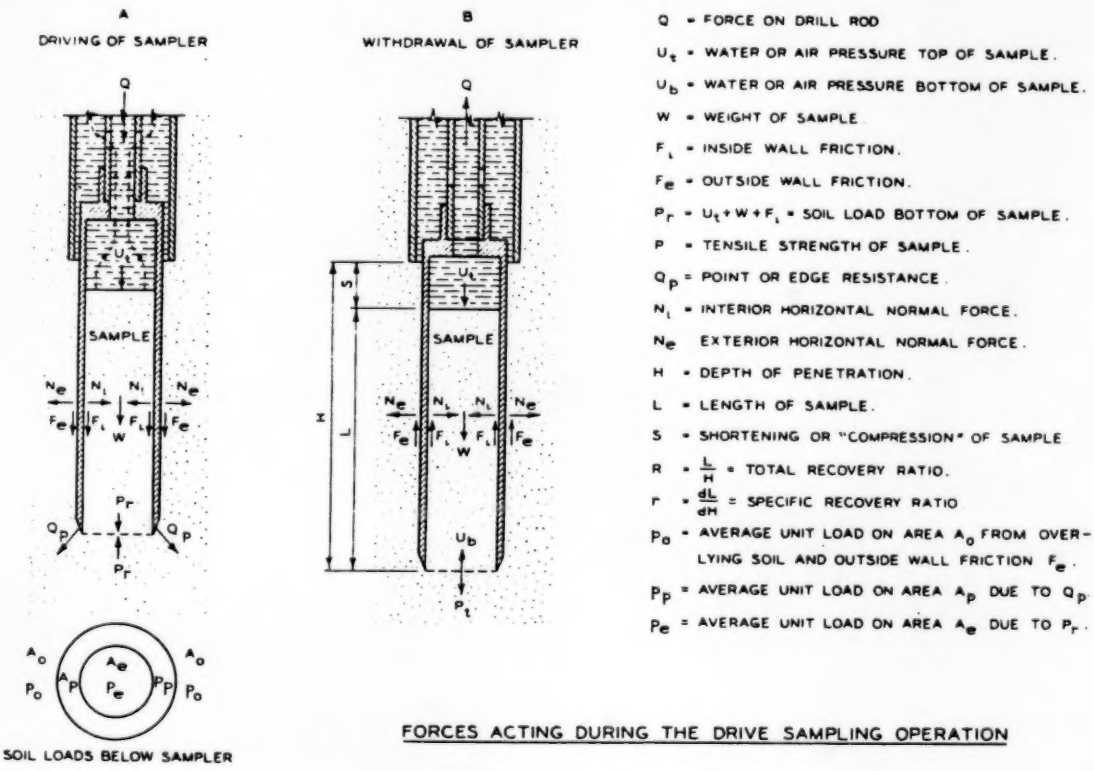
Partial or complete freezing of the soil before sampling presents fewer complications than impregnation and has been used in several instances. Langer and Kollbrunner (150, 225, 333) report successful application of partial freezing or undercooling in sampling of very loose sandy silt. Attempts to obtain samples of this soil without freezing were unsuccessful unless one of the scattered clay lenses shown in Fig. 251 was encountered at the end of a drive. Furthermore, the internal structure of the soil was so unstable that any displacement or vibration produced a considerable decrease in void ratio. The cooling was accomplished by driving five 2-1/2-in. pipes in a circle around the 6-in. boring and partially filling these pipes with a freezing mixture having a temperature of about -80°C. The freezing mixture was changed every 2 hours for a total period of about 12 hours. The temperature of the soil was thereby decreased and the viscosity of the pore water increased to such an extent that the soil acquired a consistency resembling that of a soft clay. The samples could then be obtained without material changes in void ratio and retained in a sampler similar to that shown in Fig. 197.

SAMPLING PROBLEMS (cont'd)

Since freezing and impregnation are not acceptable techniques for this particular bacteriological, we are forced to use methods which will cause structural disturbance of the material during sampling.
The sampling methods used at the Nordic Mines site, have evolved from the experiences of Can Met, Waterloo University and ourselves.
The particular problems at the Nordic Mines centre around the very loose, unconsolidated nature of the fine-grained tailings which makes them easily disturbed and the difficulty in retaining saturated samples of the material which tends to flow readily out of the bottom of sampling tubes. The latter problem was sometimes overcome, if a layer of peat existed below the sample location, by advancing the sample into the peat to form a bottom plug. We have also developed a thin wall sampler trap that closes off the end of the sampler when it is withdrawn.
A third technique used in the latter stages of this project consisted of overdriving the relatively weak aluminum tubing into the dense stoney till soils below the tailings. The overdriving caused the end of the tube to collapse and thus contain the sample during withdrawal.
To minimize the problem of disturbance (primarily by compaction in this case) a very thin-walled (0.05 ins.) aluminum tubing with a 3 inch O.D. was found to be reasonably effective. The area ratio (kerf ratio) of this tubing is about 0.07 which is much less than the 0.12 kerf ratio of a conventional 3 inch shelby tube normally used by geotechnical engineers for undisturbed sampling. Very long samples (up to 20 feet) have been recovered at the Nordic Mines using the thin walled aluminum tubing. Recovery ratios of 80% to 90% have been achieved.
(Definitions of area ratios and recovery ratios as prepared by Hvorslev are noted at the end of this report.)

METHOD OF ADVANCING SAMPLER

As indicated on the following sketch there are a number of forces which act on the sample during the sampling operation.


A
DRIVING OF SAMPLER
B
WITHDRAWAL OF SAMPLER
Q
SAMPLE
W
SOIL LOADS BELOW SAMPLER
Q = FORCE ON DRILL ROD
U_t = WATER OR AIR PRESSURE TOP OF SAMPLE.
U_b = WATER OR AIR PRESSURE BOTTOM OF SAMPLE.
W = WEIGHT OF SAMPLE
F_i = INSIDE WALL FRICTION.
F_e = OUTSIDE WALL FRICTION.
$P_r = U_t + W + F_i$ = SOIL LOAD BOTTOM OF SAMPLE.
P = TENSILE STRENGTH OF SAMPLE.
Q_p = POINT OR EDGE RESISTANCE.
N_i = INTERIOR HORIZONTAL NORMAL FORCE.
N_e EXTERIOR HORIZONTAL NORMAL FORCE.
H = DEPTH OF PENETRATION.
L = LENGTH OF SAMPLE.
S = SHORTENING OR "COMPRESSION" OF SAMPLE
$R = \frac{L}{H}$ = TOTAL RECOVERY RATIO.
$r = \frac{dL}{dH}$ = SPECIFIC RECOVERY RATIO
P_o = AVERAGE UNIT LOAD ON AREA A_o FROM OVERLYING SOIL AND OUTSIDE WALL FRICTION F_e.
P_p = AVERAGE UNIT LOAD ON AREA A_p DUE TO Q_p
P_e = AVERAGE UNIT LOAD ON AREA A_e DUE TO P_r.

FORCES ACTING DURING THE DRIVE SAMPLING OPERATION

The major forces which have to be contended with are those of friction drag (Fi) between the soil and sampler wall and the soil load (Pr) at the bottom of the sample. If the friction loads become too large there is a tendency to push soft material below the sample away from the sampler. Using straight pushing techniques did not seem to be effective at the Nordic site and I assume it was because of high friction drag.

METHOD OF ADVANCING SAMPLER (cont'd)

On the other hand very light tapping with a conventional 140 lb. drop hammer using a 2 to 6 inch drop appeared to minimize the friction effect. I believe that the reason for this is that the vibration from the hammer blows caused some liquifacation of the soil along the sides of the sample tube which reduced the friction. For this reason, the tapping techniques worked best in wet soils.

ANALYSIS OF NORDIC SITE SAMPLING

A review of the samples obtained for your study reveals that total recovery ratios ranged from 70% to 95% with an average of about 80% which is considered very good for the materials involved. Since the range of porosity of the tailings is estimated to be from 50% in the loose state to 25% in the compact state, it is therefore possible to loose 25% of the sample volume due to compaction. Which is to say that 40 cm. long sample in-situ becomes a 30 cm. long sample after compaction, even when all the material has been recovered.

I believe it reasonable to assume that on average we had about 15% loss due to compression and the other 5% was due to other causes. In other words, on average, about 95% of all the material in a given soil profile was recovered although in a more compact state than exsists in-situ.

The question of whether or not there was significant movement of water in the voids of the sample was also considered. Since the average permeability of the material is about 10^{-4} cm/sec. and since the hydraulic gradient in a standing sample tube is 1, the velocity of flow through the pores would be about 10^{-4} cm/sec. or 0.36 cm/hr. The only time available for this flow to take place was during the interval between cutting the tube and placing the sample in the receptacles. Since this time interval was usually not more than one or two minutes, the movement of pore water through the sample would have been insignificant. Moisture contents determined using the relatively large samples

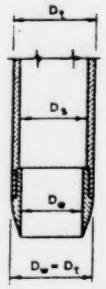
ANALYSIS OF NORDIC SITE SAMPLING (cont'd)

obtained for this project would therefore be accurate and representative.

Report prepared by

J.A. HAYES, B.Sc., D.I.C., P. Eng.,
Geotechnical Consultant for

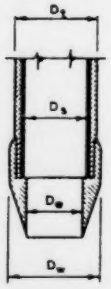
SITE INVESTIGATION SERVICES LIMITED

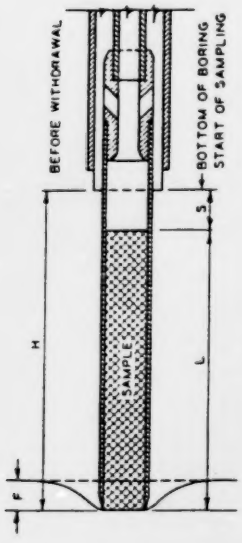


INSIDE CLEARANCE $C_i = \dfrac{D_s - D_e}{D_e}$ CONTROLS INSIDE FRICTION

OUTSIDE CLEARANCE $C_o = \dfrac{D_w - D_t}{D_t}$ CONTROLS OUTSIDE FRICTION

AREA OR KERF RATIO $C_a = \dfrac{D_w^2 - D_e^2}{D_e^2}$ $\dfrac{\text{VOLUME OF DISPLACED SOIL}}{\text{VOLUME OF SAMPLE}}$





H = DEPTH OF PENETRATION = DISTANCE ORIGINAL BOTTOM OF BORE HOLE TO CUTTING EDGE OF SAMPLER

L = ORIGINAL LENGTH OF SAMPLE = DISTANCE TOP OF SAMPLE TO CUTTING EDGE OF SAMPLER BEFORE WITHDRAWAL.

L_g = GROSS LENGTH OF SAMPLE = DISTANCE TOP OF SAMPLE TO CUTTING EDGE OF SAMPLER AFTER WITHDRAWAL.

L_n = NET LENGTH OF SAMPLE = DISTANCE TOP TO BOTTOM OF SAMPLE AFTER TRIMMING FOR SEALING.

L_t = NET LENGTH OF SAMPLING TUBE = INSIDE DISTANCE FROM CUTTING EDGE TO SAMPLE HEAD.

L/H = TOTAL RECOVERY RATIO.

$\Delta L/\Delta H$ = SPECIFIC RECOVERY RATIO.

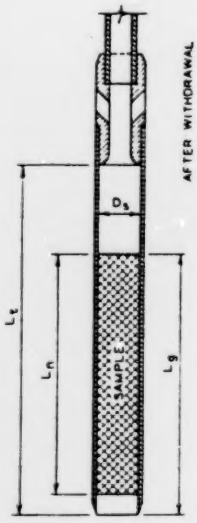
L_g/H = GROSS RECOVERY RATIO.

L_n/H = NET RECOVERY RATIO.

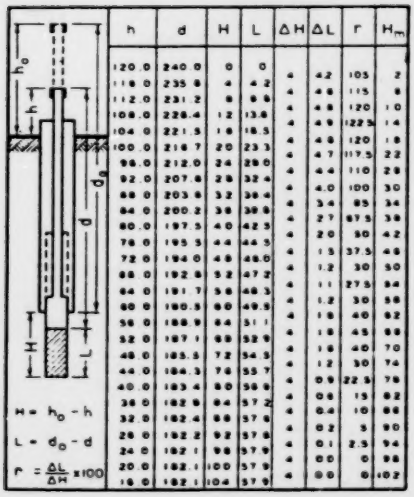
F = DEFLECTION OF SOIL AT CUTTING EDGE

$\dfrac{L}{H-F}$ = TRUE TOTAL RECOVERY RATIO

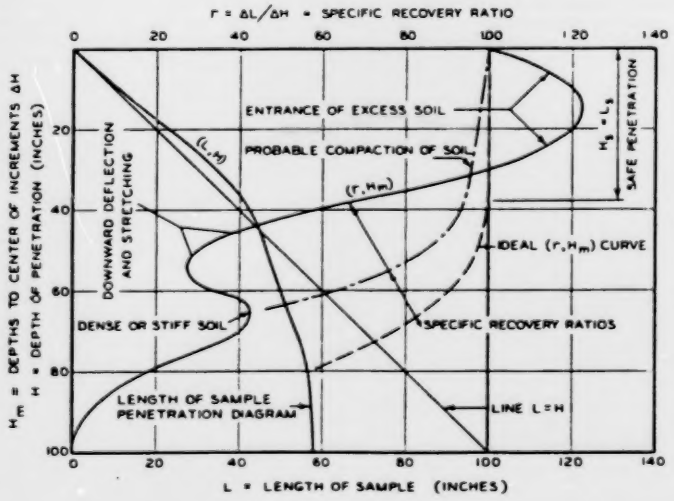
$H_s = L_s$ = SAFE PENETRATION OR SAFE LENGTH OF SAMPLE = MAXIMUM PENETRATION FOR WHICH $\Delta L = \Delta H$ AND $L = H$ CAN BE MAINTAINED = MAXIMUM LENGTH OF UNDISTURBED SAMPLE.



CHARACTERISTIC DIMENSIONS, MEASUREMENTS AND RATIOS IN DRIVE SAMPLING



h	d	H	L	ΔH	ΔL	r	H_m
120.0	240.0	0	0				
116.0	235.8	4	4.2	4	4.2	105	2
112.0	231.2	8	8.8	4	4.6	115	6
108.0	226.4	12	13.6	4	4.8	120	10
104.0	221.5	16	18.5	4	4.9	122.5	14
100.0	216.7	20	23.3	4	4.8	120	18
96.0	212.0	24	28.0	4	4.7	117.5	22
92.0	207.6	28	32.4	4	4.4	110	28
88.0	203.6	32	36.4	4	4.0	100	30
84.0	200.2	36	39.8	4	3.4	85	34
80.0	197.5	40	42.5	4	2.7	67.5	38
76.0	195.5	44	44.5	4	2.0	50	42
72.0	194.0	48	46.0	4	1.5	37.5	46
68.0	192.8	52	47.2	4	1.2	30	50
64.0	191.7	56	48.3	4	1.1	27.5	54
60.0	190.5	60	49.5	4	1.2	30	58
56.0	188.9	64	51.1	4	1.6	40	62
52.0	187.1	68	52.9	4	1.8	45	66
48.0	185.5	72	54.5	4	1.6	40	70
44.0	184.3	76	55.7	4	1.2	30	74
40.0	183.4	80	56.6	4	0.9	22.5	78
36.0	182.9	84	57.2	4	0.6	15	82
32.0	182.4	88	57.6	4	0.4	10	86
28.0	182.2	92	57.8	4	0.2	5	90
24.0	182.1	96	57.9	4	0.1	2.5	94
20.0	182.1	100	57.9	4	0.0	0	98
16.0	182.1	104	57.9	4	0.0	0	102



TYPICAL RECOVERY RATIO CURVES